Introduction

The latest routine international evaluation for females fertility traits took place as scheduled at the Interbull Centre. Data from twentyone (21) countries were included in this evaluation.

International genetic evaluations for female fertility traits of bulls from Australia, Austria, Belgium, Canada, Czech Republic, Denmark-Finland-Sweden, France, Germany, Ireland, Israel, Italy, Netherlands, New Zealand, Norway, Poland, Spain, Switzerland, South Africa, the United Kingdom, Uruguay, Japan and the United States of America and Slovenia were computed. Brown Swiss, Guernsey, Holstein, Jersey, Red Dairy Cattle and Simmental breed data were included in this evaluation.

Based on a decision made by Interbull Steering committee in August 2007, female fertility traits are classified as follows:

T1 (HC): Maiden (H)eifer's ability to (C)onceive. A measure of confirmed conception, such as conception rate (CR), will be considered for this trait group. In the absence of confirmed conception an alternative measure, such as interval first-last insemination (FL), interval first insemination-conception (FC), number of inseminations (NI), or non-return rate (NR,preferably NR56) can be submitted;

T2 (CR): Lactating (C)ow's ability to (R)ecycle after calving. The interval calving-first insemination (CF) is an example for this ability. In the abscence of such a trait, a measure of the interval calving-conception, such as says oprn (DO) or calving interval (CI) can be submitted;

T3 (C1): Lactating (C)ow's ability to conceive (1), expressed as a rate trait. Traits like conception rate (CR) and non-return rate (NR, preferably NR56) will be considered for this trait group;

T4 (C2): Lactating (C)ow's ability to conceive (2), expressed as an interval trait. The interval first insemination-conception (FC) or interval first-last insemination (FL) will be considered for this trait group. As an alternative, number of inseminations (NI) can be submitted. In the abscence of any of these traits, a measure of interval calving-conception such as days open (DO), or calving interval (CI) can be submitted. All countries are expected to submit data for this trait group, and as a last resort the trait submitted under T3 can be submitted for T4 as well.

T5 (IT): Lactating cow's measurements of (I)nterval (T)raits calving-conception, such as days open (DO) and calving interval (CI).

Based on the above trait definitions the following traits have been submitted for international genetic evaluation of female fertility traits.

Country	Traits	Submitted traits and their definitions
AUS	T4=C2	Calving interval converted to 42 days pregnancy rate
	T5=IT	Calving interval converted to 42 days pregnancy rate
BEL	T2=CY	PR=Pregnancy Rate (=[21/(DO-45+11)]*100, with DO=days open)
	T4=C2	PR=Pregnancy Rate (=[21/(DO-45+11)]*100, with DO=days open)
	T5=IT	PR=Pregnancy Rate (=[21/(DO-45+11)]*100, with DO=days open)
CAN	T1=HC	NR=Non Return Rate after 56 Days in heifers (NRR), %
	T2=CY	CF=Interval from Calving to First Service in cows(CF)
	T3=C1	NR=Non Return Rate after 56 Days in cows(NRR), %
	T4=C2	FC=Interval first insemination-conception in cows
	T5=IT	DO=Days open
CHE	T1=HC	CR=Heifers' Conception rate
	T2=CR	CF=Interval from Calving to First Service (ICF), days
	T3=C1	NR=Non Return Rate after 56 Days (NRR), %
	T4=C2	FL=Interval from first to last insemination cows
CZE	T1=HC	CR=Heifers' Conception rate (pregnant or not after 3 months)

	T3=C1	CR=Cows’ Conception rate (pregnant or not after 3 months)
	T4=C2	CR=Cows’ Conception rate (pregnant or not after 3 months)
AUT/DEU	T1=HC	NR=Heifers’ Non Return Rate after 56 days
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	NR=Cows’ Non Return Rate after 56 days
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
DFS	T1=HC	CR=Heifers’ Conception rate for maiden heifers
	T2=CY	CF=Interval from calving to first insemination cows (days)
	T3=C1	CR=Cows’ conception rate for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=Days open (days)
ESP	T2=CY	Interval from Calving to First Service (ICF)
	T3=C1	Conception rate
	T4=C2	Interval first insemination to conception
	T5=IT	Days Open
FRA	T1=HC	CR=Heifers’ Conception rate (binary trait) for maiden heifers
	T2=CY	Interval between calving and first AI
	T3=C1	CR=Cows’ Conception rate (binary trait)
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	FL=Interval from first to last insemination cows (days)
GBR	T2=CY	CI=days between 1st and 2nd calvings
	T3=C1	NR=1st lactation non return at 56 days
	T4=C2	CI=days between 1st and 2nd calvings
	T5=IT	CI=days between 1st and 2nd calvings
IRL	T2=CY	CI=Calving interval
	T4=C2	CI=Calving interval
	T5=IT	CI=Calving interval
ISR	T3=C1	CR=Inverse of the number of insemination to conception (%)
	T4=C2	CR=Inverse of the number of insemination to conception (%)
ITA	T1=HC	NR= non-return rate 56 days (heifers)
	T2=CY	CF=Days to first service
	T3=C1	NR=Non-return rate at 56 days (%)
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	DO=days open (days)
ITA(BSW)	T2=CY	CF=Interval calving to first insemination
	T4=C2	Days Open
	T5=IT	CI=Calving interval
NLD	T1=HC	CR=Heifers’ Conception rate
	T2=CY	CF=Interval calving to first insemination (days)
	T3=C1	CR=Cows’ Conception rate (binary trait) for cows
	T4=C2	FL=Interval from first to last insemination cows (days)
	T5=IT	CI=Days Open
NOR	T1=HC	NI=Number of inseminations (heifers)
	T2=CY	CF=Days from calving to first insemination (days)
	T3=C1	NI=Number of inseminations (cows)
	T4=C2	NI=Number of inseminations (cows)
	T5=IT	CF=Days from calving to first insemination (days)
NZL	T2=CY	PM=Lactating cow’s ability to start cycling
	T4=C2	CR= Cow’s conception rate at 42 days
	T5=IT	CR= Cow’s conception rate at 42 days
POL	T1=HC	CR=Conception Rate (heifer)
	T2=CR	CF=Interval from calving to first insemination
	T3=C1	CR=Conception Rate (cow)
	T4=IT	DO=Days open
	T5=IT	DO=Days open

URY	T4=C2	Days open expressed as Daughter Pregnancy Rate
	T5=IT	Days open expressed as Daughter Pregnancy Rate
USA	T1=HC	CR=Conception rate (heifer)
	T2=CY	CF=Interval from calving to first insemination
	T3=C1	CR=Conception rate (cow)
	T4=C2	DP=Daughter Pregnancy Rate
	T5=IT	DP=Daughter Pregnancy Rate
ZAF	T4=IT	CI=Calving Interval
	T5=IT	CI=Calving Interval
JPN	T1=HC	CR=Heifers'Conception rate
	T3=C1	CR=Cows'Conception rate
	T4=C2	DO=Days open
	T5=IT	DO=Days open
SVN	T5=IT	CI=Calving interval (days)

CHANGES IN NATIONAL PROCEDURES

Changes in the national genetic evaluation of female fertility traits are as follows:

DFS (ALL)	Records for each cow are checked with calving informations, and if they do not match, the fertility record is deleted, this causes drops in EDC
DEA (BSW)	Base change
IRL (HOL,JER,RDC)	Slight decrease in information due to database clean ups
BEL (HOL)	Some bulls with type of proof showing an unexpected change are due to the program used to determine the type of proof for bulls
AUS (ALL)	Drops of information due to data clean up such as pedigree changes or status changes leading to a good number of bulls no longer being qualified. Decreases in EDC are also due to rounding.
ITA (HOL)	Base change plus 1 year cutoff data.
SVN (HOL,BSW)	Participating with the first time to INT evaluation, base change
DEU (ALL)	Herd-years with uninformative NonReturn56, i.e., 100% NR56 ae excluded. Some traits are verified with the subsequent calving, e.g. interval first to last insemination, insemination dates must match with calving dates and result in reasonable gestation length. Thus there are always some bulls having number of herds/daughters/EDC decreased, being not publishable anymore or in case number of herds drop below 10 herds, bulls are even not sent anymore. Base change
CHE (ALL)	Base change. Decrease in information due to manual edits in the database
ITA (BSW)	Base change
POL (HOL)	Decrease in information due to data editings
NZL (ALL)	Daughter counts: New Zealand has continuous DNA parentage testing so daughters will always change, Herd Count: Affected by continuous DNA parentage testing. EDCs: Affected by continuous DNA parentage testing. Reliability changes. The AB Companies have a Short Gestation Length scheme in NZL where they have been selecting bulls who will have shorter gestation. It was decided to remove the daughters of these bulls from the Fertility extract so that the fact the bulls had short gestation did not over inflate the Fertility BV incorrectly. This change affects the reliability of some bulls.
NLD (ALL)	HCO:Heritability discovered too high and corrected
CAN (ALL)	Base change
GBR (ALL)	Drop in information due to data clean up
USA (ALL)	Excluded fertility information from herds not correctly reporting ET, causing drops in information. Pedigree corrections and herd-year minimum edits causing drops in information
FRA (ALL)	Base change
CZE (HOL)	6 months period of inseminations trimmed.

INTERBULL CHANGES COMPARED TO THE PREVIOUS ROUTINE RUN

Post-processing Windows:

According to the decision taken by ITC in Orlando (2015) to review the post-processing windows every 5 years, during the 2020 the relative working group has been re-activated and new windows have been identified.

As before, the upper bounds have been set to 0.99 as these were judged to have

very little effect on evaluations while the lower values have been reduced
to the 10th percentile. This reduction would provide post-processed correlations to be closer to the
real estimated ones. Over the past five years, in fact, the previous adopted lower value (25th percentile) had been found too high
causing estimated and post-processed correlations to differ significantly from each other.
The new lower values have been applied to all breeds and traits.

The weight assigned to the magnitude of the changes tested by each country has also been revised. The new weight will allow post-processed correlations
to take more in consideration the value of the new estimated ones even when no changes are applied by the countries.
The new weights are as follows:
No changes   :: 2
Small changes:: 1
Big changes :: 0

More information can be read on https://interbull.org/ib/rg_procedure

DATA AND METHOD OF ANALYSIS

Data were national genetic evaluations of AI sampled bulls with at least
10 daughters or 10 EDC (for clinical mastitis and maternal calving traits at least
50 daughters or 50 EDC, and for direct calving traits at least 50 calvings or 50 EDC) in at
least 10 herds. Table 1 presents the amount of data included
in this Interbull evaluation for all breeds.

National proofs were first de-regressed within country and then analysed
jointly with a linear model including the effects of evaluation country,
genetic group of bull and bull merit. Heritability estimates used in both
the de-regression and international evaluation were as in each country's
national evaluation.

Table 2 presents the date of evaluation as supplied by each country

Estimated genetic parameters and sire standard deviations are shown in APPENDIX I
and the corresponding number of common bulls are listed in APPENDIX II.

SCIENTIFIC LITERATURE

The international genetic evaluation procedure is based on international work
described in the following scientific publications:

International genetic evaluation computation:

     Schaeffer. 1994. J. Dairy Sci. 77:2671-2678
     Klei, 1998. Interbull Bulletin 17:3-7

Verification and Genetic trend validation:

     Klei et al., 2002. Interbull Bulletin 29:178-182.
     Boichard et al., 1995. J. Dairy Sci. 78:431-437

Weighting factors:

     Fikse and Banos, 2001. J. Dairy Sci. 84:1759-1767

De-regression:

     Sigurdsson and G. Banos. 1995. Acta Agric. Scand. 45:207-219
     Jairath et al. 1998. J. Dairy Sci. Vol. 81:550-562

Genetic parameter estimation:

     Klei and Weigel, 1998, Interbull Bulletin 17:8-14
     Sullivan, 1999. Interbull Bulletin 22:146-148

Post-processing of estimated genetic correlations:

     Mark et al., 2003, Interbull Bulletin 30:126-135
     Jorjani et al., 2003. J. Dairy Sci. 86:677-679
     https://wiki.interbull.org/public/rG%20procedure?action=print

Time edits

Weigel and Banos. 1997. J. Dairy Sci. 80:3425-3430

International reliability estimation
Harris and Johnson. 1998. Interbull Bulletin 17:31-36

NEXT ROUTINE INTERNATIONAL EVALUATION

Dates for the next routine evaluation can be found on
http://www.interbull.org/ib/servicecalendar.

NEXT TEST INTERNATIONAL EVALUATION

Dates for the next test run can be found on
http://www.interbull.org/ib/servicecalendar.

PUBLICATION OF INTERBULL ROUTINE RUN

Results were distributed by the Interbull Centre to designated representatives in each country. The international evaluation file comprised international proofs expressed on the base and unit of each country included in the analysis. Such records readily provide more information on bull performance in various countries, thereby minimizing the need to resort to conversions.

At the same time, all recipients of Interbull results are expected to honor the agreed code of practice, decided by the Interbull Steering Committee, and only publish international evaluations on their own country scale. Evaluations expressed on another country scale are confidential and may only be used internally for research and review purposes.

PUBLICATION OF INTERBULL TEST RUN

Test evaluation results are meant for review purposes only and should not be published.

^LTable 1. National evaluation data considered in the Interbull evaluation for fertility (April Routine Evaluation 2022).
Number of records for lactating cow’s ability to conceive (cc2) by breed

Country	BSW	GUE	HOL	JER	RDC	SIM
AUS		143	8513	1818	761	
BEL			2022			
CAN	178	47	9919	606	577	
CHE	2923		3148			
CZE			3755			
DEA	4814					
DEU			24787		299	
DFS			16853	2460	10341	
ESP			6084			
EST						
FRA	421		16967			
FRM						
GBR	107	243	7345	599	432	
HUN						
IRL			3092	209	68	
ISR			1580			
ITA	1898		9290			
JPN			6298			
KOR						
LTU						
LVA						

NLD	209		16205	208	91	
NOR					3044	
NZL	53	49	8181	4760	1300	
POL			8439			
PRT						
SVK						
SVN						
URY			1828			
USA	1159	776	41082	5132	767	
ZAF			1272	735	154	
HRV						
CAM						
No.Records	11762	1258	196660	16527	17834	
Pub. Proofs	10494	1041	155702	13813	17730	0

^LAPPENDIX I. Sire standard deviations in diagonal and genetic correlations below diagonal

BSW hco

	CAN	DEA	FRA	USA	CHE	NLD
CAN	9.81					
DEA	0.86	9.96				
FRA	0.77	0.86	0.89			
USA	0.78	0.78	0.88	2.67		
CHE	0.91	0.94	0.87	0.81	13.23	
NLD	0.77	0.63	0.72	0.74	0.63	4.43

BSW crc

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.84								
CHE	0.83	11.39							
DEA	0.79	0.95	14.89						
NLD	0.85	0.89	0.89	3.89					
NZL	0.60	0.62	0.73	0.62	0.12				
USA	0.78	0.84	0.82	0.81	0.61	8.01			
GBR	0.71	0.71	0.64	0.77	0.63	0.73	3.78		
FRA	0.82	0.96	0.95	0.91	0.64	0.84	0.74	1.78	
ITA	0.82	0.79	0.79	0.82	0.66	0.79	0.75	0.82	16.73

BSW cc1

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	7.86						
CHE	0.82	11.82					
DEA	0.78	0.94	11.46				
NLD	0.77	0.71	0.67	4.03			
USA	0.75	0.68	0.67	0.85	2.87		
GBR	0.76	0.80	0.78	0.73	0.67	0.03	
FRA	0.73	0.69	0.67	0.87	0.89	0.71	0.96

BSW cc2

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	6.76								
CHE	0.77	11.13							
DEA	0.78	0.93	12.21						
NLD	0.85	0.84	0.83	3.41					
NZL	0.70	0.66	0.73	0.70	5.93				
USA	0.82	0.83	0.84	0.82	0.70	2.46			
GBR	0.73	0.81	0.83	0.76	0.70	0.82	3.78		
FRA	0.84	0.87	0.88	0.86	0.70	0.83	0.79	0.96	

ITA	0.81	0.70	0.79	0.82	0.67	0.82	0.77	0.78	21.89

BSW int

	CAN	DEA	NLD	NZL	USA	GBR	ITA	SVN
CAN	7.22							
DEA	0.81	14.19						
NLD	0.87	0.91	3.38					
NZL	0.68	0.80	0.69	5.93				
USA	0.91	0.85	0.83	0.67	2.46			
GBR	0.83	0.79	0.86	0.67	0.84	3.78		
ITA	0.85	0.92	0.88	0.68	0.82	0.83	17.62	
SVN	0.70	0.68	0.71	0.72	0.69	0.72	0.69	20.28

GUE crc

	CAN	GBR	NZL	USA	AUS
CAN	7.95				
GBR	0.74	5.10			
NZL	0.61	0.63	0.12		
USA	0.78	0.77	0.61	6.89	
AUS	0.68	0.79	0.89	0.66	6.97

GUE cc1

	CAN	GBR	USA
CAN	7.57		
GBR	0.76	0.03	
USA	0.80	0.72	3.45

GUE cc2

	CAN	GBR	NZL	USA	AUS
CAN	7.02				
GBR	0.72	5.10			
NZL	0.69	0.70	5.81		
USA	0.85	0.81	0.70	2.75	
AUS	0.68	0.68	0.69	0.73	9.78

GUE int

	CAN	GBR	NZL	USA	AUS
CAN	7.82				
GBR	0.83	5.10			
NZL	0.67	0.67	5.81		
USA	0.91	0.81	0.67	2.75	
AUS	0.75	0.72	0.72	0.75	9.78

HOL hco

	CAN	CZE	DEU	DFS	FRA	USA	POL	CHE	NLD	ITA	JPN
CAN	7.80										
CZE	0.77	18.12									
DEU	0.91	0.80	15.22								
DFS	0.79	0.85	0.84	13.53							
FRA	0.81	0.82	0.81	0.88	0.84						
USA	0.84	0.86	0.84	0.87	0.89	2.37					
POL	0.64	0.59	0.64	0.59	0.59	0.61	19.73				
CHE	0.96	0.82	0.93	0.80	0.85	0.87	0.61	13.79			
NLD	0.78	0.77	0.81	0.85	0.83	0.83	0.57	0.80	5.08		
ITA	0.81	0.79	0.92	0.76	0.77	0.81	0.69	0.88	0.74	0.04	
JPN	0.85	0.72	0.83	0.72	0.78	0.84	0.64	0.85	0.74	0.74	6.23

HOL crc

	BEL	CAN	CHE	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	FRA
BEL	4.70													
CAN	0.75	7.28												
CHE	0.81	0.83	12.29											
DEU	0.72	0.84	0.87	10.99										
DFS	0.79	0.87	0.94	0.92	11.64									
ESP	0.86	0.84	0.87	0.85	0.87	11.07								
GBR	0.90	0.74	0.77	0.72	0.79	0.86	4.58							
IRL	0.85	0.62	0.67	0.61	0.63	0.77	0.82	3.53						
ITA	0.80	0.86	0.87	0.87	0.86	0.91	0.81	0.67	7.82					
NLD	0.82	0.87	0.93	0.90	0.96	0.87	0.79	0.63	0.85	4.89				
NZL	0.61	0.60	0.61	0.58	0.62	0.63	0.63	0.55	0.70	0.59	0.09			
USA	0.73	0.78	0.82	0.81	0.86	0.82	0.78	0.59	0.80	0.82	0.60	6.80		
POL	0.76	0.89	0.89	0.85	0.84	0.89	0.75	0.68	0.95	0.84	0.68	0.76	13.50	
FRA	0.78	0.85	0.94	0.92	0.94	0.88	0.79	0.66	0.90	0.94	0.62	0.82	0.88	1.18

HOL cc1

	CAN	CHE	CZE	DEU	DFS	FRA	GBR	ISR	ITA	NLD	USA	POL	JPN
CAN	6.68												
CHE	0.92	10.91											
CZE	0.83	0.75	17.67										
DEU	0.91	0.92	0.80	14.75									
DFS	0.75	0.70	0.88	0.77	13.16								
FRA	0.78	0.75	0.90	0.75	0.88	1.01							
GBR	0.76	0.77	0.70	0.78	0.66	0.72	0.03						
ISR	0.77	0.67	0.91	0.75	0.86	0.87	0.74	3.24					
ITA	0.87	0.86	0.79	0.95	0.70	0.73	0.78	0.76	0.05				
NLD	0.79	0.76	0.90	0.79	0.92	0.94	0.73	0.88	0.74	4.83			
USA	0.80	0.71	0.95	0.74	0.85	0.87	0.67	0.92	0.77	0.87	2.80		
POL	0.72	0.75	0.73	0.76	0.64	0.65	0.66	0.68	0.80	0.67	0.67	19.75	
JPN	0.77	0.74	0.89	0.75	0.83	0.81	0.75	0.83	0.75	0.82	0.91	0.67	7.61

HOL cc2

	BEL	CAN	CHE	CZE	DEU	DFS	ESP	FRA	GBR	IRL	ISR	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	JPN
BEL	4.70																			
CAN	0.77	6.12																		
CHE	0.82	0.90	10.95																	
CZE	0.66	0.87	0.86	17.67																
DEU	0.80	0.93	0.92	0.91	13.49															
DFS	0.82	0.85	0.88	0.82	0.94	12.82														
ESP	0.84	0.83	0.86	0.86	0.89	0.84	11.06													
FRA	0.82	0.88	0.93	0.84	0.92	0.86	0.88	0.98												
GBR	0.89	0.73	0.74	0.66	0.78	0.81	0.81	0.76	4.58											
IRL	0.84	0.78	0.83	0.69	0.81	0.78	0.83	0.82	0.83	3.53										
ISR	0.65	0.74	0.74	0.88	0.83	0.78	0.82	0.77	0.64	0.69	3.24									
ITA	0.76	0.86	0.86	0.90	0.92	0.84	0.89	0.85	0.78	0.79	0.88	15.27								
NLD	0.82	0.89	0.90	0.86	0.96	0.92	0.87	0.92	0.77	0.81	0.80	0.86	4.50							
NZL	0.70	0.69	0.63	0.63	0.69	0.69	0.65	0.69	0.69	0.69	0.62	0.63	0.69	4.61						
USA	0.81	0.86	0.85	0.88	0.90	0.87	0.87	0.81	0.83	0.82	0.82	0.92	0.84	0.69	2.33					
POL	0.82	0.74	0.73	0.63	0.73	0.74	0.76	0.73	0.82	0.79	0.64	0.80	0.73	0.69	0.79	13.03				
ZAF	0.77	0.78	0.83	0.72	0.82	0.76	0.82	0.79	0.79	0.87	0.67	0.84	0.76	0.63	0.87	0.82	15.42			
AUS	0.69	0.68	0.73	0.63	0.70	0.64	0.71	0.71	0.69	0.85	0.63	0.70	0.66	0.62	0.73	0.62	0.80	8.04		
URY	0.74	0.72	0.66	0.62	0.72	0.72	0.68	0.72	0.74	0.74	0.57	0.64	0.72	0.72	0.72	0.75	0.78	0.67	1.40	
JPN	0.84	0.82	0.85	0.77	0.84	0.85	0.85	0.81	0.87	0.85	0.71	0.87	0.81	0.69	0.92	0.90	0.88	0.72	0.75	18.39

HOL int

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	FRA	JPN	SVN
BEL	4.70																	
CAN	0.88	6.59																
DEU	0.86	0.91	12.32															

DFS	0.90	0.91	0.95	12.75														
ESP	0.90	0.88	0.88	0.88	11.06													
GBR	0.89	0.84	0.86	0.89	0.88	4.58												
IRL	0.85	0.84	0.83	0.81	0.87	0.83	3.53											
ITA	0.86	0.89	0.90	0.89	0.93	0.87	0.84	19.94										
NLD	0.93	0.91	0.92	0.96	0.89	0.88	0.83	0.88	4.58									
NZL	0.71	0.66	0.66	0.66	0.67	0.66	0.66	0.66	0.66	4.61								
USA	0.83	0.93	0.91	0.88	0.90	0.84	0.83	0.92	0.86	0.66	2.33							
POL	0.82	0.87	0.81	0.83	0.84	0.83	0.80	0.91	0.83	0.68	0.81	13.04						
ZAF	0.80	0.85	0.85	0.82	0.87	0.82	0.87	0.87	0.82	0.66	0.88	0.85	15.42					
AUS	0.75	0.76	0.74	0.72	0.76	0.74	0.85	0.74	0.71	0.66	0.75	0.72	0.82	8.04				
URY	0.75	0.72	0.72	0.72	0.72	0.73	0.76	0.75	0.71	0.73	0.71	0.76	0.82	0.73	1.40			
FRA	0.81	0.87	0.81	0.81	0.85	0.73	0.80	0.81	0.82	0.66	0.81	0.71	0.79	0.72	0.65	0.98		
JPN	0.86	0.93	0.90	0.90	0.90	0.87	0.85	0.94	0.88	0.66	0.92	0.91	0.89	0.76	0.77	0.80	18.39	
SVN	0.84	0.69	0.70	0.79	0.78	0.72	0.73	0.77	0.80	0.67	0.68	0.66	0.67	0.67	0.67	0.76	0.72	18.07

JER hco

	CAN	DFS	USA	NLD
CAN	7.92			
DFS	0.74	17.23		
USA	0.80	0.84	2.73	
NLD	0.82	0.84	0.75	4.80

JER crc

	CAN	DFS	GBR	NLD	NZL	USA	IRL
CAN	6.70						
DFS	0.82	13.47					
GBR	0.67	0.84	4.00				
NLD	0.85	0.87	0.73	3.90			
NZL	0.55	0.70	0.67	0.57	0.07		
USA	0.77	0.83	0.79	0.80	0.66	8.15	
IRL	0.64	0.63	0.81	0.63	0.56	0.60	2.23

JER cc1

	CAN	DFS	GBR	NLD	USA
CAN	7.10				
DFS	0.72	15.34			
GBR	0.78	0.67	0.03		
NLD	0.77	0.85	0.71	3.75	
USA	0.75	0.84	0.67	0.79	2.91

JER cc2

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.80								
DFS	0.82	15.56							
GBR	0.74	0.77	4.00						
NLD	0.86	0.88	0.76	3.28					
NZL	0.70	0.70	0.69	0.70	3.99				
USA	0.81	0.82	0.80	0.81	0.71	2.61			
ZAF	0.67	0.66	0.73	0.69	0.77	0.85	11.14		
AUS	0.65	0.66	0.65	0.66	0.62	0.67	0.73	6.14	
IRL	0.77	0.75	0.78	0.78	0.70	0.78	0.77	0.73	2.23

JER int

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	6.44								
DFS	0.86	15.32							
GBR	0.79	0.84	4.00						
NLD	0.87	0.90	0.82	3.42					

NZL	0.67	0.67	0.68	0.67	3.99					
USA	0.85	0.84	0.81	0.80	0.70	2.61				
ZAF	0.75	0.75	0.77	0.76	0.77	0.86	11.14			
AUS	0.73	0.73	0.73	0.72	0.66	0.73	0.77	6.14		
IRL	0.81	0.75	0.77	0.79	0.67	0.77	0.80	0.77	2.23	

RDC hco

	CAN	DEU	DFS	NOR	USA	NLD
CAN	7.59					
DEU	0.90	14.15				
DFS	0.73	0.80	12.25			
NOR	0.86	0.89	0.86	16.40		
USA	0.83	0.83	0.85	0.71	2.75	
NLD	0.81	0.83	0.77	0.66	0.80	5.46

RDC crc

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	IRL
CAN	6.47								
DEU	0.84	10.03							
DFS	0.84	0.89	12.66						
GBR	0.77	0.72	0.71	4.14					
NOR	0.84	0.82	0.85	0.64	13.86				
NZL	0.57	0.59	0.55	0.64	0.59	0.11			
USA	0.78	0.81	0.80	0.76	0.77	0.70	8.36		
NLD	0.87	0.89	0.93	0.77	0.83	0.60	0.81	3.63	
IRL	0.62	0.62	0.64	0.82	0.63	0.57	0.61	0.63	2.80

RDC cc1

	CAN	DEU	DFS	GBR	NOR	NLD	USA
CAN	7.11						
DEU	0.90	13.42					
DFS	0.72	0.80	12.98				
GBR	0.76	0.79	0.68	0.03			
NOR	0.78	0.86	0.92	0.76	13.96		
NLD	0.79	0.80	0.89	0.72	0.73	4.14	
USA	0.83	0.75	0.81	0.67	0.75	0.85	2.71

RDC cc2

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.78										
DEU	0.92	11.21									
DFS	0.82	0.94	12.80								
GBR	0.74	0.78	0.78	4.14							
NOR	0.81	0.85	0.89	0.76	13.96						
NZL	0.70	0.70	0.70	0.71	0.72	5.71					
USA	0.87	0.89	0.82	0.80	0.76	0.70	2.47				
ZAF	0.72	0.81	0.76	0.71	0.77	0.65	0.83	17.57			
NLD	0.88	0.95	0.88	0.77	0.80	0.71	0.84	0.76	3.59		
AUS	0.67	0.68	0.64	0.67	0.65	0.63	0.69	0.70	0.66	7.43	
IRL	0.78	0.81	0.78	0.81	0.76	0.70	0.80	0.84	0.81	0.80	2.80

RDC int

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	6.64										
DEU	0.90	11.07									
DFS	0.88	0.94	13.12								
GBR	0.83	0.85	0.82	4.14							
NOR	0.80	0.79	0.73	0.74	13.86						
NZL	0.68	0.68	0.67	0.69	0.69	5.71					

USA	0.92	0.90	0.81	0.82	0.74	0.67	2.47					
ZAF	0.83	0.85	0.80	0.77	0.84	0.68	0.85	17.57				
NLD	0.90	0.92	0.94	0.86	0.76	0.68	0.83	0.81	3.45			
AUS	0.75	0.74	0.73	0.74	0.74	0.67	0.75	0.77	0.67	7.43		
IRL	0.83	0.83	0.80	0.82	0.74	0.68	0.80	0.86	0.81	0.83	2.80	

^LAPPENDIX II. Number of common bulls

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEA	FRA	USA	CHE	NLD
CAN	0	92	53	103	96	29
DEA	82	0	194	188	576	130
FRA	45	145	0	72	163	73
USA	94	147	54	0	201	51
CHE	80	484	122	165	0	94
NLD	26	123	60	47	89	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	119	115	39	17	134	48	72	109
CHE	101	0	590	102	26	266	65	164	441
DEA	101	489	0	150	38	232	62	202	580
NLD	34	94	138	0	25	61	38	80	126
NZL	16	20	33	19	0	17	13	21	31
USA	130	231	180	56	14	0	67	93	170
GBR	45	49	46	33	10	65	0	48	71
FRA	62	121	149	63	16	63	40	0	183
ITA	96	375	465	102	25	119	51	138	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	USA	GBR	FRA
CAN	0	121	117	40	135	48	77
CHE	102	0	589	101	266	67	172
DEA	102	487	0	150	232	65	215
NLD	35	94	138	0	61	38	84
USA	131	231	180	56	0	69	98
GBR	46	52	49	33	68	0	53
FRA	66	128	161	68	69	46	0

BSW

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	CHE	DEA	NLD	NZL	USA	GBR	FRA	ITA
CAN	0	106	100	36	14	128	45	68	97
CHE	87	0	582	102	23	321	65	172	441
DEA	88	483	0	151	32	306	62	214	578
NLD	32	94	138	0	20	84	38	84	126
NZL	13	17	27	14	0	24	10	17	25
USA	120	297	261	73	20	0	77	118	217
GBR	41	49	46	33	7	75	0	51	71
FRA	60	128	160	68	12	83	44	0	196
ITA	85	375	464	102	21	151	51	150	0

BSW

----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN DEA NLD NZL USA GBR ITA SVN

  CAN   0 104   37   14 133   47 103   31
  DEA   91   0 150   32 305   62 674   96
  NLD   33 138   0   20   84   38 131   46
  NZL   13   27   14   0   24   10   25   8
  USA 125 261   73   20   0   77 239   40
  GBR   43   46   33   7   75   0   73   21
  ITA   90 593 108   21 170   53   0   94
  SVN   28   91   47   7   34   17   94   0

GUE

GUE
----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN GBR NZL USA AUS

  CAN   0   16   2   39   18
  GBR   13   0   14   52   28
  NZL   1   12   0   10   25
  USA   38   49   7   0   19
  AUS   13   22   23   16   0

GUE
----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN GBR USA

  CAN   0   18   40
  GBR   14   0   55
  USA   39   52   0

GUE
----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN GBR NZL USA AUS

  CAN   0   11   0   38   23
  GBR   8   0   13   82   32
  NZL   0   11   0   24   23
  USA   36   84   23   0   64
  AUS   19   26   23   62   0

GUE
----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN GBR NZL USA AUS

  CAN   0   11   0   38   23
  GBR   8   0   13   82   32
  NZL   0   11   0   24   23
  USA   36   84   23   0   64
  AUS   19   26   23   62   0

HOL
----
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN CZE DEU DFS FRA USA POL CHE NLD ITA JPN

  CAN   0 1061 2205 1305 1267 2881 1279 807 1355 1798 1119

```
 CZE  784    0 1796 1198 1201 1432 1139  482 1463 1283  800
 DEU 1768 1367    0 2512 2299 2911 2162 1104 3006 2608 1297
 DFS 1216  805 1879    0 1640 1636 1322  712 2149 1602  950
 FRA  942  734 1296  950    0 1657 1431  696 1921 1666 1116
 USA 3311 1151 2275 1470  996    0 1807  868 1832 2413 1433
 POL 1158  903 1889 1084  962 1880    0  530 1545 1491  805
 CHE  728  339 1030  657  639  799  419    0  889  755  454
 NLD 1333 1271 2640 1861 1266 1624 1378  881    0 1742 1042
 ITA 1568  935 1848 1327 1002 2009 1195  701 1477    0 1144
 JPN  626  346  575  497  408  745  433  292  520  537    0
```

HOL

```
 common bulls below diagonal
 common three quarter sib group above diagonal
      BEL  CAN  CHE  DEU  DFS  ESP  GBR  IRL  ITA  NLD  NZL  USA  POL  FRA
 BEL    0  760  599 1205  852  889  857  517  803 1236  513  814  557  958
 CAN  764    0  838 2333 1391 1528 1612  558 1826 1500  712 3012 1159 1371
 CHE  607  767    0 1142  715  708  742  421  750  934  428  927  486  712
 DEU 1231 1824 1076    0 2699 2219 2222  922 2627 3486 1024 3155 1914 2536
 DFS  799 1302  669 1980    0 1490 1606  762 1579 2181  856 1784 1208 1661
 ESP  962 1318  669 1953 1307    0 1478  708 1656 1692  738 1795 1125 1717
 GBR  838 1692  706 1692 1263 1350    0 1011 1627 1874  970 2025 1019 1605
 IRL  511  558  434  809  643  730 1052    0  641  924  755  672  392  761
 ITA  808 1593  699 1871 1307 1482 1320  578    0 1801  716 2520 1307 1668
 NLD 1414 1492  933 3196 1953 1784 1648  877 1568    0 1105 2094 1402 2047
 NZL  414  655  356  785  611  612  833  652  558 1000    0  853  448  813
 USA  778 3524  861 2382 1563 1549 1970  659 2040 1882  788    0 1632 1862
 POL  466 1018  366 1565  947  901  772  300  978 1211  332 1599    0 1323
 FRA  949 1033  646 1427  949 1628 1046  620 1001 1335  498 1098  845    0
```

HOL

```
 common bulls below diagonal
 common three quarter sib group above diagonal
      CAN  CHE  CZE  DEU  DFS  FRA  GBR  ISR  ITA  NLD  USA  POL  JPN
 CAN    0  840 1050 2333 1398 1379 1665  125 1841 1511 3077 1203 1259
 CHE  768    0  454 1139  715  716  757   58  749  934  927  508  482
 CZE  818  321    0 1676 1094 1094  958  113 1214 1378 1448 1098  756
 DEU 1823 1071 1324    0 2701 2552 2263  165 2615 3471 3127 2062 1486
 DFS 1307  669  801 1977    0 1669 1638  148 1578 2180 1789 1295 1009
 FRA 1051  654  671 1444  961    0 1632  119 1672 2063 1869 1376 1251
 GBR 1752  725  666 1738 1293 1072    0  145 1673 1927 2101 1074 1100
 ISR   90   35   86  132  110   67  105    0  139  155  161  106  103
 ITA 1612  697  919 1857 1304 1014 1373  103    0 1799 2514 1367 1189
 NLD 1502  933 1249 3180 1952 1360 1708  122 1564    0 2094 1516 1106
 USA 3602  861 1179 2348 1563 1113 2067  156 2035 1882    0 1694 1628
 POL 1077  400  883 1803 1066  903  841   77 1050 1370 1690    0  812
 JPN  738  333  380  659  561  475  582   47  605  609  892  452    0
```

HOL

```
 common bulls below diagonal
 common three quarter sib group above diagonal
      BEL  CAN  CHE  CZE  DEU  DFS  ESP  FRA  GBR  IRL  ISR  ITA  NLD  NZL  USA  POL  ZAF  AUS  URY  JPN
 BEL    0  751  599  552 1197  853  889  949  859  519   75  801 1238  496  967  551  330  743  342  519
 CAN  754    0  832 1031 2271 1375 1515 1340 1587  546  122 1793 1473  653 3174 1123  442 1294  713 1165
 CHE  607  754    0  454 1133  716  708  706  742  421   59  747  934  409 1025  474  264  640  304  448
 CZE  441  788  321    0 1671 1094 1047 1085  947  433  113 1214 1378  484 1513 1020  294  731  467  721
 DEU 1223 1749 1064 1316    0 2688 2219 2513 2211  917  166 2586 3445  967 3674 1859  556 1713  786 1404
 DFS  799 1279  670  801 1964    0 1498 1659 1610  762  150 1574 2184  821 2177 1185  509 1310  632  949
 ESP  962 1289  669  846 1945 1314    0 1719 1481  709  133 1654 1697  714 2112 1104  516 1190  649 1097
 FRA  936  998  638  662 1385  935 1614    0 1600  764  121 1648 2029  797 2553 1295  480 1312  595 1186
 GBR  838 1657  706  662 1674 1263 1351 1036    0 1012  144 1621 1877  933 2403  997  502 1453  671 1039
 IRL  511  539  434  330  802  643  730  615 1052    0   97  640  927  739  838  383  335  757  373  451
 ISR   45   87   35   86  131  110  102   66  103   78    0  138  157  106  186  100   60  111   83  101
```

ITA	806	1542	696	918	1824	1295	1477	976	1316	577	103	0	1792	677	2679	1274	453	1178	658	1125
NLD	1416	1454	933	1249	3127	1954	1787	1307	1649	878	122	1556	0	1042	2656	1358	503	1509	669	1040
NZL	396	592	338	358	725	577	588	479	801	640	88	528	937	0	1088	413	353	1191	520	553
USA	862	3619	959	1211	2610	1700	1819	1384	2215	763	174	2098	2324	1026	0	1630	633	1983	1121	1932
POL	455	966	352	776	1490	921	879	815	752	291	64	945	1158	304	1566	0	227	752	443	741
ZAF	276	406	222	203	426	376	473	335	441	294	39	369	419	281	609	153	0	474	312	407
AUS	642	1315	566	510	1277	956	964	894	1275	654	71	922	1310	1180	2000	540	414	0	656	892
URY	252	669	229	315	548	432	565	347	539	293	45	480	517	421	1374	339	263	508	0	556
JPN	320	608	284	331	555	480	511	404	498	276	38	512	516	264	767	369	256	462	275	0

HOL

common bulls below diagonal
common three quarter sib group above diagonal

	BEL	CAN	DEU	DFS	ESP	GBR	IRL	ITA	NLD	NZL	USA	POL	ZAF	AUS	URY	FRA	JPN	SVN
BEL	0	753	1195	853	889	859	519	800	1238	496	967	550	330	743	342	949	519	178
CAN	758	0	2276	1383	1522	1596	552	1800	1483	658	3188	1126	446	1302	718	1348	1170	203
DEU	1222	1758	0	2685	2218	2211	917	2585	3442	967	3669	1852	556	1713	785	2512	1404	317
DFS	799	1289	1961	0	1498	1610	762	1574	2183	821	2175	1184	509	1310	631	1659	949	252
ESP	962	1305	1945	1314	0	1481	709	1653	1696	714	2110	1104	516	1189	649	1718	1096	241
GBR	838	1670	1674	1263	1351	0	1012	1621	1877	933	2403	997	502	1453	670	1600	1039	212
IRL	511	547	802	643	730	1052	0	640	927	739	838	383	335	757	373	764	451	123
ITA	806	1554	1824	1295	1476	1316	577	0	1792	677	2679	1270	453	1178	658	1648	1125	247
NLD	1416	1467	3126	1953	1787	1649	878	1556	0	1042	2656	1355	503	1509	669	2029	1040	266
NZL	396	595	725	577	588	801	640	528	937	0	1088	413	353	1191	520	797	553	125
USA	862	3649	2610	1700	1819	2215	763	2098	2324	1026	0	1628	633	1983	1121	2553	1932	243
POL	455	972	1487	920	879	752	291	944	1158	304	1566	0	227	752	443	1295	740	213
ZAF	276	413	426	376	473	441	294	369	419	281	609	153	0	474	312	480	407	90
AUS	642	1320	1277	956	964	1275	654	922	1310	1180	2000	540	414	0	656	1312	892	177
URY	252	675	548	432	565	539	293	480	517	421	1374	339	263	508	0	595	556	94
FRA	936	1006	1385	935	1614	1036	615	976	1307	479	1384	815	335	894	347	0	1186	208
JPN	320	611	555	480	511	498	276	512	516	264	767	369	256	462	275	404	0	163
SVN	145	156	307	198	213	159	96	212	231	86	187	174	64	123	51	148	88	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	USA	NLD
CAN	0	89	324	28
DFS	84	0	141	74
USA	312	128	0	62
NLD	21	71	61	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	IRL
CAN	0	95	145	35	161	375	12
DFS	88	0	170	132	150	158	51
GBR	146	165	0	89	215	210	73
NLD	31	129	83	0	78	85	30
NZL	161	127	222	71	0	285	128
USA	378	145	228	89	308	0	42
IRL	11	47	75	30	144	44	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	USA
CAN	0	96	149	35	382
DFS	89	0	170	131	157
GBR	148	165	0	89	214

NLD	31	128	84	0	85
USA	385	145	231	89	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	93	142	35	146	380	129	219	12
DFS	86	0	171	132	147	205	153	161	51
GBR	141	165	0	89	209	238	172	222	73
NLD	30	129	83	0	72	99	74	74	30
NZL	144	123	217	66	0	369	208	431	127
USA	381	180	263	105	441	0	311	504	49
ZAF	127	135	175	70	218	324	0	245	41
AUS	212	131	229	68	476	545	233	0	60
IRL	11	47	75	30	143	51	42	58	0

JER

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DFS	GBR	NLD	NZL	USA	ZAF	AUS	IRL
CAN	0	94	143	35	148	383	131	221	12
DFS	87	0	171	132	147	205	153	161	51
GBR	143	165	0	89	209	238	172	222	73
NLD	31	129	83	0	72	99	74	74	30
NZL	148	123	217	66	0	369	208	431	127
USA	387	180	263	105	441	0	311	504	49
ZAF	130	135	175	70	218	324	0	245	41
AUS	216	131	229	68	476	545	233	0	60
IRL	11	47	75	30	143	51	42	58	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	NOR	USA	NLD
CAN	0	10	170	7	100	6
DEU	10	0	56	14	16	10
DFS	177	47	0	123	158	55
NOR	6	13	101	0	69	39
USA	94	15	151	69	0	38
NLD	6	10	52	39	36	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	NLD	IRL
CAN	0	13	171	72	7	69	140	6	4
DEU	12	0	60	14	15	18	20	14	5
DFS	178	48	0	104	144	170	184	57	19
GBR	73	13	101	0	56	73	95	37	23
NOR	6	14	116	59	0	46	77	44	57
NZL	69	18	166	72	45	0	102	20	15
USA	136	19	179	92	77	105	0	42	28
NLD	6	14	54	36	44	20	40	0	12
IRL	4	5	14	22	56	15	28	12	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NLD	USA

CAN	0	13	171	77	7	6	141
DEU	12	0	57	14	14	14	20
DFS	178	45	0	111	131	57	184
GBR	77	13	107	0	58	37	98
NOR	6	13	107	61	0	42	77
NLD	6	14	54	36	42	0	42
USA	137	19	179	94	77	40	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	0	13	167	68	7	59	166	74	6	71	4
DEU	12	0	56	14	14	15	21	3	14	41	5
DFS	173	45	0	104	131	157	209	59	57	213	19
GBR	69	13	101	0	55	69	109	44	37	79	23
NOR	6	13	107	58	0	36	81	0	42	67	57
NZL	60	15	153	67	35	0	104	37	17	129	12
USA	168	20	206	108	81	106	0	74	46	130	29
ZAF	78	3	56	41	0	35	69	0	3	44	3
NLD	6	14	54	36	42	17	44	3	0	31	12
AUS	72	39	189	78	56	129	130	45	29	0	17
IRL	4	5	14	22	56	12	29	3	12	16	0

RDC

common bulls below diagonal
common three quarter sib group above diagonal

	CAN	DEU	DFS	GBR	NOR	NZL	USA	ZAF	NLD	AUS	IRL
CAN	0	13	167	69	7	59	166	74	6	71	4
DEU	12	0	56	14	14	15	21	3	14	41	5
DFS	173	45	0	104	144	157	209	59	57	213	19
GBR	70	13	101	0	56	69	109	44	37	79	23
NOR	6	13	116	59	0	37	81	0	44	71	57
NZL	60	15	153	67	36	0	104	37	17	129	12
USA	168	20	206	108	81	106	0	74	46	130	29
ZAF	78	3	56	41	0	35	69	0	3	44	3
NLD	6	14	54	36	44	17	44	3	0	31	12
AUS	72	39	189	78	60	129	130	45	29	0	17
IRL	4	5	14	22	56	12	29	3	12	16	0

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